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ABSTRACT

Changes in the economy and the workplace are changing job skill requirements and the process of skill acquisition. A study analyzed occupational trends and projections, performed case studies of four industry sectors (apparel and textile, accounting, management consulting, and software development), and reviewed research on changing skill demands and educational responses. Conflicting views of job skills emerged--whether jobs would increasingly become "deskilled" or require increasingly higher order skills. Intensified competition, changing demand for goods and services, and an accelerated rate of change necessitate economic restructuring. Coping with these conditions requires changes in the organization of companies and industries and in relationships between suppliers and customers. There are implications for education and training in the changes in the relative numbers of high- and low-skilled positions, a more uncertain and less well-defined environment, and more complex interactions among people. Whether and how much of the preparation of the work force should take place in schools or the workplace is at question. One conclusion is that rather than deskilling, technological advances demand more conceptual and problem-solving abilities at all levels of the employment hierarchy. The traditional distinctions between academic and vocational education are being challenged, and learning must now be viewed as a continuous, lifelong process. (Includes an appendix on occupational structure, 6 tables, and 86 references.) (CML)

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CHANGES IN THE NATURE AND STRUCTURE OF WORK: IMPLICATIONS FOR SKILL REQUIREMENTS AND SKILL FORMATION

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INTRODUCTION

Profound changes are taking place in the economy and labor market of the United States. These developments in turn have far-reaching effects on the skills needed in the workplace and on the educational process both in the school, college, and university systems and in the firms themselves. In light of what many observers believe is a new era in the society and economy of the United States, policymakers and analysts have become increasingly concerned that the education and training system in this country is not adequate to play its expected role in assuring individual opportunity, in promoting growth and prosperity in the economy as a whole, and in strengthening the country's ability to compete in an increasingly global economy.

The changes in the nature of work are being brought about by many factors. On the demand side of the labor market, there have been increases in international trade, changes in the economic position of the United States relative to its trading partners, a continuing increase in the role of services in all sectors of the economy, the diffusion of computers and sophisticated communications equipment, changes in the nature of markets and consumer demand, and a general increase in the level of change and uncertainty. Developments on the supply side of the labor market may be equally as important. These include the increasing average levels of education and the depletion of reserves of labor that have in the past come into the economy at low levels. These have included pools of farm-based labor in rural areas in the United States, women not engaged in paid labor, and the large cohorts of young people from the "baby boom." None of these sources is likely to provide large increments of low level labor over the next decade.

These developments appear to have created conditions that represent a decisive break with the earlier post-World War II era. In many industries, these developments have brought about profound changes in markets, technologies, work organization, and industry structure which in turn have reshaped human resource strategies and educational and training requirements.

This report is focused on the effects of changes in the economy and the workplace in two broad areas. The first involves changes in the skills required on the job. The second is concerned with the institutional process through which those skills are acquired—in

particular, the changing relative roles of the outside educational system and in-firm training in preparing the country's workforce.

The skill and educational implications of new technology and of changes in the structure of the economy continue to generate controversy. The central issue in this debate has been whether new technology, especially computer-based technology, has led to a reduction or an increase in skills required at the lower and middle levels of the employment hierarchy. This report attempts to gauge the direction of the change in skill requirements, but also to develop a better qualitative understanding of the nature of the changes in skill requirements that are taking place.

The changes in technology and work also have implications for the relative roles of training and education in schools and in the workplace in preparing the nation's workforce. Some analysts have argued that there has been a weakening of opportunities for employees to achieve occupational mobility by moving up a job ladder within firms. This was a particularly important route to stable employment for workers with low levels of educational attainment. In the early 1980s, however, it seemed that the system of mobility based on internal promotion within a firm was giving way to a system in which mobility depended more on acquiring formal education and credentials from outside educational institutions. This seemed to contradict other evidence that firms were actually devoting more effort and resources to internal training.

Methodology

The research program on which this report is based combined analyses of occupational trends and projections, detailed case studies of four industry sectors—apparel and textile manufacturing and financial and business services (primarily accounting, management consulting, and software development)—and a general review of research on the issue of changing skill demands and educational responses.[1]

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[1]Unless otherwise stated, the material in this summary concerning these four industries is drawn from individual reports on each of those industries. See Bailey, 1988, 1989; Bertrand & Noyelle, 1988; and Noyelle, 1989.

Through case studies it was possible to analyze at a concrete level the interactions among changing markets, changing technology, changing labor supplies, changing skill requirements, and changing educational processes. In order to make the results more general, the industries were chosen to provide variation along the two dimensions—manufacturing and service—that expose fundamental characteristics of the changes underway. The sample included two manufacturing and two service industries. One of the most common views of the changing economy is that it is shifting from a manufacturing-based to a service-based economy. The second dimension was the extent to which the industry was traditionally oriented toward capital intensive mass production of standardized goods or whether its business process was based more on labor intensive production of a more varied and customized product or service. This contrast was chosen because there is a growing acceptance of the contention that a fundamental feature of the current transformation of the economy is a shift from a mass production orientation to a greater emphasis on more flexible and customized production. Banking and textiles have traditionally produced large quantities of standardized commodities while business services and apparel have had to be capable of delivering a more varied and faster changing set of products and services.

The case studies involved extensive background research on each of the industries using secondary sources and the industry press. Representatives of employer associations, unions, consultants, and other experts in the industries were interviewed. For the case studies, field work was carried out in nine textile firms, thirteen apparel firms (at seventeen factories), five business services firms, and twelve banks and insurance companies. Two of the banks were in the United States. The remaining banks and insurance companies were in France, Sweden, Germany, and Japan. Visits were also made to seven schools, specialized training facilities, or postsecondary institutions that train personnel for the textile and apparel industries. There were also interviews at one consulting firm extensively involved with training for the apparel and textile industries. The field work consisted of one or two days of interviews at each of the sites. The choice of interviews depended on the size and organization of the firm. In large firms we talked to representatives of top management, personnel and training administrators, individuals involved with development and acquisition of technology and software, plant managers, and production level supervisors.

This report also uses occupational projections for the economy as a whole to analyze the trends in skills and education. Data from the 1988 Current Population Survey on education levels of occupations was matched to projections of occupational growth from the Bureau of Labor Statistics (BLS). This analysis indicates whether occupations that are currently filled with workers with higher educational levels are projected to grow faster or more slowly than those in which the incumbents have relatively little education, thus indicating trends in overall skill requirements in the economy.

The second section reviews the controversy about skills and technology. Section three discusses the current economic restructuring and its effect on the nature of work. The fourth section presents the implications of the changes in the economy and work on the occupational structure. (The Appendix analyzes the occupational data in more detail.) It also considers how the changes in work are affecting the skills needed on the job and the relative role of schools and the workplace in preparing the nation's workforce. The final section serves three purposes. First, it points out how this report and the research program that it discusses fits into and influences the debates outlined in the second section. The second part addresses whether the argument which is developed here, based primarily on case studies, can be generalized to other industries or to the economy as a whole. The last part presents some policy directions.

TECHNOLOGY AND SKILLS: THE CONTROVERSY

During the post-World War II era, rising educational levels and advances in automation suggested that the evolving economy would require ever-increasing skills. According to the modernization theory, evolved primarily in the study of developing economies, the growth of productive technologies inevitably would displace workers from direct involvement in the production process, freeing them for higher-order activities. Bell's influential book, *The Coming of the Post-Industrial Society*, published in 1973, which went well beyond the arena of the less developed countries, represented, perhaps, the height of this modernist view. Bell argued that

> in the Scientific City of the future, there are already foreshadowed three classes: The creative elite of scientists and the top professional

> administrator (can one call them the "new clerisy," in Coleridge's term?); the middle class of engineers and the professoriate; the proletariat of technicians, junior faculty, and teaching assistants. (pp. 214-215)

Bell's class structure left no room for manual and unskilled labor.

Empirical investigations of manufacturing plants by analysts such as Walker (1958) and Blauner (1964) during the 1950s and 1960s seemed to provide support for this optimistic view. These authors saw the continuous processing plant as the basic paradigm of the future. Walker concluded after a multi-year study of a semiautomatic seamless steel mill, that

> the evidence suggests that partial automation, or some types of it, may retain repetitiveness and may sometimes increase tension; complete automation is needed to remove these characteristics from work. (p. 113)

Walker's description of the skill implications of "complete" automation should sound familiar to participants in the current debates about skill changes. He stated that

> what was called for in the new mill was skill different in *kind*: skills of the head rather than the hand, of the logician rather than the craftsman, of nerve rather than muscle, of the pilot rather than the manual worker, and of the maintenance man rather than the operator. (p. 113)

But Bell's book came just as the quarter century of buoyant American growth and optimism was coming to an end. Correspondingly, skepticism about the effect of technological change began to grow. The sharpest and most influential attack on the modernist, post-industrial perspective came from Braverman (1974) who argued that in a modern capitalist economy, technology was used to reduce the skills needed by production workers, in both manufacturing and services. Modern technology might require highly skilled managers, engineers, and planners, but the production workers who used it would be engaged in simple routine tasks and have absolutely no say in what they did or how they did it.

Braverman (1974) argued that capitalists sought to wrest control of the production process from skilled workers and used technology to achieve that control. Levin (1987) used more mainstream economic theory to argue that modern firms are organized in such a way as to limit the need for skill and initiative on the part of workers. Drawing on developments in the economic theory of the firm, Levin argued that modern production processes require that workers operate interdependently. As a result, individual productivity is extremely difficult to measure. When individual productivity cannot be measured, the

worker has an incentive to shirk—an individual worker can get the benefit of the joint production without the work as long as others produce. According to Levin,

> the solution to the problem requires a form of organization for the firm in which information on worker effort can be readily obtained and disciplinary action readily taken. Such an organization requires routinization and simplification of worker tasks and hierarchy. The routinization and simplification of worker tasks enables supervisors to more easily judge the effort of workers in a common endeavor. (p. 199)

That is to say, modern management of complex production processes requires simplification and managerial control of the lower level tasks.

During the last half of the 1970s and in the early 1980s, Braverman's (1974) argument spawned a proliferation of case studies of the labor process. Studies of clerical workers (Glenn & Feldberg, 1977), computer programming (Kraft, 1977; Greenbaum, 1979), printing (Zimbalist, 1979; Wallace & Kalleberg, 1982), and machine manufacturing (Shaiken, 1984) all found evidence of deskilling. According to these studies, Braverman was right. Modern technology was being used to deskill the jobs of production workers who were divested of any control over their work.

However, this presumed deskilling was taking place while average educational levels were rising. Indeed, during the 1970s, several analysts argued that many Americans were acquiring more education than they needed for the jobs that were available (Berg, 1970; Freeman, 1976; Rumberger, 1981). As more people obtained education, employers could choose among the more highly educated even when the jobs could easily be done by less-educated recruits. This conclusion was supported by evidence that employers were no longer willing to pay much more for college graduates. Freeman (1976) showed that the increase in income resulting from a college education, in comparison to the income of those with no more than a high school education, fell sharply during the early 1970s. The most recent analysis, by Murphy and Welch (1989), showed that during the late 1960s, college graduates with one to five years of experience earned about forty-five percent more than high school graduates, but that the differential had fallen to just over thirty percent by 1975. Other studies matched average educational levels of occupations to measures of education "needed" for those occupations. For example, Rumberger (1984) found that college enrollments tripled between 1960 and 1980, but the number of jobs requiring a college education only doubled.

If the overeducation thesis could explain why deskilling was taking place while education levels were rising, life-cycle theories of technological change were used to explain why overall needs might be falling even though advanced skills were needed by those working with some new technologies. The concept was first advanced by a Harvard Business School professor, James Bright, in the 1950s and 1960s. Bright argued that advanced skills were required for new technologies, but once a technology matured, the skills needed to work, operate, and maintain it fell. More recently, after reviewing one hundred and ninety-seven case studies published between 1940 and the mid-1980s, Flynn (1988) came to similar conclusions.

Most case studies were concerned with changes in the content of jobs. Changes in the composition of the occupational structure can also affect the overall skill demands of the economy. For example, the relative growth of professional jobs and the relative decline of laborer jobs would shift up skill requirements even if there were no changes in the content of those jobs. Research on changes in occupational composition is usually based on the occupational projections generated by the BLS; this data is sometimes used to show that some low-skilled occupations, janitors, for example, are expected to add large numbers of jobs to the economy. Some analyses of the entire occupational distribution have also concluded that occupations requiring lower educational levels will grow more quickly than those requiring higher levels of education. For example, Levin and Rumberger (1987) used occupational projections and data on job openings due to employee turnover to show that while in 1982 sixty-four percent of the employed workers in the country had zero to twelve years of schooling, sixty-nine percent of the projected job openings (due to job growth and turnover) would require no more than a high school degree.

By the early 1980s, the deskilling view was popular and widely accepted, but there were some dissenting views. Some case studies began to challenge the deskilling notion (Adler, 1986; Hirschorn, 1988). Attempts to test the deskilling thesis using broad-based data, rather than case studies, failed to provide any support. The Department of Labor's *Workforce 2000* analyzed occupational projections and showed faster growth of those occupations held by more highly skilled workers (Johnston & Packer, 1987). Many studies used the *Dictionary of Occupational Titles* (DOT) (U.S. Department of Labor, 1977) to examine changes in the skills needed within occupations. The DOT was designed to survey periodically the changing characteristics of thousands of individual occupations. Unfortunately, any results about changing characteristics derived from this data are made

unreliable by methodological problems. Neither the DOT's list of occupations nor its occupational definitions were fully updated. Hence, many of the newest occupations or suboccupations are simply missing, and between three-quarters and four-fifths of the descriptions are identical in the last two rounds of the survey (Spenner, 1983; Miller, Treiman, Cain, & Roos, 1980). In any case, the research based on the DOT failed to support the deskilling perspective. Spenner's (1985) review of this research suggested, if anything, a slight overall tendency toward upgrading, despite the bias that this data has against change.

During the last half of the 1980s, the deskilling hypothesis came under increasing attack. A growing number of case studies, including the four carried out as part of the present research program, do not find a proliferation of powerless low-skilled workers and, in many cases, find increasing skill demands. To some extent, this controversy simply involves an empirical issue, but one for which a solution is thwarted by the absence of widely accepted measures of skills. The body of case study research suggests that the terms in which the debate has been carried out have been misleading. First, the discussion has been based on a narrow and simplistic conception of occupations and jobs and of the relationship between technology and work. The effects of the introduction of a given technology or a particular change in work organization can look different depending on whether the analyst looks at specific tasks or at broader effects on the overall division of labor. Second, much of the debate has been ahistorical. Analysts talk about the effects of "technological" change or "modern" technology, often mixing examples from the entire postwar era. The same technology can have different effects depending on the historical context in which it is introduced. Moreover, the current historical period makes increasingly misleading the narrow definitions of skills and occupations on which much of the research is based.

The remainder of this section focuses on the pitfalls of a narrow definition of jobs and tasks and of the effects of technology. The implications of the current historical period are addressed in the next section.

Technology, Work Organization, Jobs, and Tasks

"What are the effects of the new technology?" is often the first question asked in the debate about changing work and skills. There is no question that new technology has transformed work, but the search for the direct effects of new technology has been misleading and confusing. This confusion is compounded by a tendency to view a job as a set of well-defined tasks. Rumberger (1987) states that "it is assumed that each job consists of a fixed number of tasks that require a certain array of skills to perform them" (p. 27). Evaluating the "effects of technology" on a given job, therefore, involves adding up the effects on each task.

Certainly it is not difficult to find examples of tasks and collections of tasks that have been made simpler by new technology. Perhaps the most common is the ubiquitous description of changes in fast-food cash registers. In many outlets, standard cash registers with numbered buttons have been replaced by machines that have little pictures of hamburgers and french fries printed on the keys. This could be the ultimate example of deskilling. Fast-food restaurants can now make do with employees who do not read or recognize numbers. The explosion of the fast-food sector during the late 1960s and the 1970s made this example even more compelling in that in 1967, fast-food restaurants accounted for nineteen percent of restaurant sales in the United States. By 1982, their share had risen to 38.5% (Bailey, 1987, p. 64). In fact, employment at McDonald's became the popular conception of employment in the new service economy.

While the fast-food example had wide popular appeal, the example of changes in machinists' skills was most influential in the scholarly literature. Braverman (1974) had presented a detailed description of changes in the jobs of machinists, and some of the best-known proponents of the deskilling view leaned on it heavily (Noble, 1977, 1984; Shaiken, 1984; Shaiken, Herzenberg, & Kuhn, 1986). Perhaps the power of this argument came from the extent to which people believed that machinists were the quintessential blue-collar craftsmen—well paid and highly skilled. According to the argument, the introduction of numerically controlled machine tools robbed them of skill, status, and control. All of the mental work was now done by engineers and programmers in an office, and the microelectronic controls, rather than the skilled machinist's hands, guided the material as it was cut. Workers who were once high-status craftsmen were reduced to mere machine loaders.

Our case studies revealed tasks that were simplified by new technology. For example, accounting software simplifies some bookkeeping tasks. Fixing yarn breaks on textile looms, once a demanding responsibility, has been made easier by looms that rarely break the yarn or that can repair the break if it does occur. Programmable sewing machines can, under some circumstances, transform skilled sewing tasks into semiskilled machine-tending tasks.

But other examples reveal the potential problems in determining the effects of technology on a collection of tasks. Consider the case of the effect of word processing on the task of producing a business letter. Certainly word processing allows poor typists to turn out perfectly typed business letters, so in that sense, word processing simplifies the task. But since executives, administrators, and professionals are now more likely to produce their own letters, the educational level of those carrying out this task has probably risen. On the other hand, the current activities of workers who previously typed letters are determined by how work was reorganized, if it was, after the introduction of word processing.

Two other popular concepts of the relationship between technology and skills, both of which are still commonly heard, have also been misleading. One suggested that all jobs in "high-tech" manufacturing industries required higher skills and the other, that all individuals working with computers required special skills.

Examples could be found to show that sophisticated electronics firms employed low-skilled workers, as suggested by the title of a frequently cited article by Levin and Rumberger (1983), "The Low Skill Future of High-Tech." Grubb (1984) has also made a similar argument that has received attention in the education literature. Examples of individuals somehow working with computers who have no need of advanced skills are also easy to find. As Goldstein and Fraser (1985) stated:

> It may seem paradoxical that such widespread use of technology many people associate with abstruse mathematics and electronics can be attained with relatively little special education and training . . . to understand this, one needs to recall that such innovations as automobiles, television, plastics, telephones and electricity have become nearly universal while requiring relatively few highly-trained workers, mostly engineers and crafts workers in their manufacture, installation, or repair. The computer is becoming prevalent mainly because it has been designed and constantly and ingeniously improved to make it easy to use. (p. 3)

Both the "high-tech" and computer-operator arguments are couched in task-oriented terms based on narrow views of the relationship between skills and technology. Trends in skills and in the nature of jobs for workers in "high-tech" industries or those who come into contact with computers cannot be evaluated without considering broader changes in work organization and the division of labor.

The simple deterministic model that conceptualizes technological change as an exogenous force that has well-defined implications for required skills may still hold sway in some popular discussions, but our analysis of technology in four industries, as well as a great deal of research on technology and work over the last decade, has explicitly rejected this notion. Zuboff (1988) presents several detailed examples of applications of similar information systems in factories and offices that contrast sharply with each other in terms of such factors as the "firm's commitment to participatory management." Our research in the textile and garment industries revealed a wide range of applications of the same technology, sometimes the same machines, with radically different implications for skills and human resource strategies. The answer to the question, "What is the effect of microelectronic technology on work and skills?" is almost always a resounding, "It depends."

But this is an unsatisfactory conclusion. If "it depends," what does it depend on and can something be said about the current effects and future implications of those underlying determinants? Braverman (1974) argued that the fundamental cause of deskilling was not technology but the capitalist drive to control the process of production. Levin (1987) argued that the need to supervise shirking workers in a complex production process drove the trend toward the simplification and routinization of work. The argument developed below is that current changes in markets, consumer demand, industrial structure, and the labor supply are having a particular effect on skills and work. These changes are making it more difficult to use technology to reduce skills. Adjusting to these changes is requiring critical reappraisal of human resource strategy. Understanding the evolution of work requires fundamental alterations in the way that we conceptualize and categorize jobs and occupations.

INTENSIFIED COMPETITION AND CHANGING MARKETS

Several critical trends in the last twenty years have shaped the nature of work and skills. To be sure, the influence of technology cannot be ignored. New technology and microelectronics in particular have transformed both the nature of the products and the characteristics of the production processes in banking and business services. For example, the proliferation of products and services sold by financial institutions was only possible through the use of microelectronics, and the globalization of financial services is based on the communications and transactions capabilities of the computer linked to modern telecommunications. Computers have also taken over many of the routine functions in banks and insurance companies. Computers have had just as profound an effect on business services. Microelectronics technology has automated the routine work in accounting and is crucial for the analysis and research on which consulting projects are based. The fastest growing segments of business services directly involve the design and application of computer software and hardware. Here computing is not just a means to produce the output but is itself the output.

Although microelectronics has not had such a profound effect on the output of the textile and apparel sectors, it has been widely used to transform the production and distribution process in these traditional industries. In addition to this, investments in new technology have been particularly widespread in the textile industry. Modern weaving and spinning plants still have looms and spinning frames, but otherwise appear to have little in common with the satanic mills of the industrial revolution. In 1960, the textile industry ranked forty-eighth out of sixty-one manufacturing industries in terms of its average equipment age (the industry ranked first had the newest equipment). By 1980, the industry's rank had risen to second. This modernization has led to impressive gains in productivity. While total factor productivity in the manufacturing sector in the United States grew 2.4% a year between 1975 and 1985, textile productivity grew by 5.6% a year during the same period.

The effect of technology on apparel production has been less spectacular. Most garments are still sewn together by an individual operator pushing the material through a sewing machine. Nevertheless, the potential of programmable equipment is only beginning to be realized, and productivity gains in this labor intensive industry have at least kept up with the solid gains that the entire manufacturing sector has experienced during the 1980s.

The use of technology to transform the links between the textile and apparel sectors has probably had at least as much effect on the transformation of these industries as the applications of technology to the production process itself.

The Causes of Economic Restructuring

But changes in the structure of the economy and related developments in work and skills cannot be understood by looking at technology alone. Drawing on material from the four study industries and from other research, three additional factors should be emphasized: the intensification of competition, particularly international competition; changes in the nature of demand for goods and services; and the general increase in uncertainty and in the pace of change in technology, production processes, and markets. The emerging strategies that firms and industries are using to respond to the challenges that confront them also needs to be discussed.

Competition

In the last twenty years, markets for the products of each of the four industries have shifted from being overwhelmingly domestic to becoming almost completely integrated into a global market. In banking, internationalization of capital markets and wholesale banking functions for large commercial clients, which began with the rise of Eurodollar markets in the late 1960s, has gone the farthest. In the late 1980s the market for medium-sized corporate clients in the United States has come under attack from Japanese and European banks, and there is even some evidence for international competition in consumer banking. The breakup of national markets for financial services has been further advanced by foreign purchases of United States banks.

Before 1965, imported apparel and textiles accounted for less than ten percent of the domestic textile market. By 1980, the United States imported 4.9 billion square yard equivalents of textile products (including imported raw fabric and the fabric contained in imported garments and other textile products) which accounted for seventeen percent of the market for textiles and textile equivalents in apparel and other products. By 1988, imports accounted for over thirty-five percent of the market. In that same year, over fifty-five

percent of apparel fabric consumed in the United States was imported (Unpublished data provided by the American Textile Manufacturers Institute, August, 1989).

The internationalization of markets has of course extended well beyond the industries that we have studied. The share of United States Gross National Product (GNP) accounted for by imports and exports rose from ten percent in 1960 to twenty-two percent in 1984 (OTA, 1988, p. 303). Moreover, the concern of domestic producers is not simply that trade has increased, but rather that the balance of trade has shifted against the United States.

The acceleration of international competition precipitated many changes both in the way that goods and services were produced and in the intellectual debate about changes in skills. For example, the publication of *A Nation at Risk* by the National Commission on Excellence in Education in 1983 set off a virtual revolution in thinking about education. It argued that the country would fall behind in international competition unless it drastically improved its educational system. Although the report did not provide definitive evidence to support this claim, its conclusions became the conventional wisdom overnight. The report did not present new evidence on the skill needs of the economy, but its widespread acceptance suggested that, whatever the evidence, most people were prepared to accept the argument that many of the nation's problems in international competition arose from its supposedly wretched educational system. Once this was accepted, support for the notion that modern production technologies required ever-decreasing skills was more difficult to find. Indeed, the early 1980s period was probably the apogee of the deskilling position, and its decline coincided with the linking of international competition to the educational reform movement of the 1980s.

Changes in the Nature of Markets

Changes in the nature of consumer demand have interacted with the internationalization of markets to further change the nature of work. In 1984, Piore and Sabel argued that during the postwar era, advanced firms, especially in the United States, had prospered by developing processes to produce low-cost, standardized goods for a mass market.[2]

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[2]Piore and Sabel made one of the first comprehensive statements about the need for increasing flexibility. Some of their notions about the role of small technologically advanced firms in achieving a flexible production system have been challenged. Nevertheless, there is wide acceptance for their argument that changes in consumer

Low-cost production has always been associated with economies of scale. Indeed, production-process innovation in the United States in the twentieth century has been synonymous with capital intensive mass production. But the scope for profitable pursuit of this type of strategy depends on strong markets for standardized goods or services. As industrial societies matured, consumers increasingly sought greater variety and higher quality, and markets for standardized commodity items shrank.

Although there are still many opportunities to produce white underwear or corn flakes, these types of basic commodities account for a diminishing share of the markets. In each of the four industries we studied, a few basic goods or services have given way to dozens of items; and completely customized products are increasing in importance (see OTA, 1988, Chapter 2, for a discussion of trends in consumption patterns in the economy as a whole). This has involved a shift from growth based primarily on increased sales of standardized goods or services to attempts to sell more varied and customized products.

For example, in banking, through the mid-1970s, consumer banks focused their marketing efforts on bringing new clients into the banking system. In the 1960s, approximately twenty-five percent of United States households had checking and savings accounts, while by the early 1980s, almost ninety percent of United States households had such accounts. Rising household incomes not only created a demand for very basic banking services, but also increased the market for much more specialized consumer financial instruments. While, fifteen years ago, consumer banks in the United States offered six basic products, today, customers in the most progressive retail banks can choose from over one hundred products. The acceleration of growth of extraordinarily complex financial transactions during the 1980s forced banks to develop hundreds of new financial instruments, many of which were unique for individual deals. Moreover, the technology itself has allowed the creation of the array of these new products and services.

Many functions of business service firms are inherently customized. Management consultants have to try to solve the particular problems of individual clients. They may have standard models, but the models must be applied to unique circumstances. The same

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demand have broken up mass markets, thus favoring firms or groups of firms that can produce small quantities of goods or services and can react flexibly to market shifts. Hayes, Wheelwright, and Clark (1988) present a more recent statement of the need for flexible manufacturing and suggest how it can be achieved. Neither of these sets of authors focuses on the skill and training implications.

can be said for systems analysis and design. Even if standard systems can be used, almost all applications must be customized for the particular needs of clients. There are still many routine functions in accounting, but these are precisely those functions that can be eliminated or sharply reduced through the use of computers and accounting software. In the case of business services, the growth of the sector itself is an indication of the trend toward customization and more varied output.

Although fashion has always been important at the upper ends of the apparel markets, during the last two decades changing style and fashion have come to dominate much larger segments of the market. Innovative designers and producers (initially most of these were foreign) saw potential markets for fashion-oriented products for middle-income consumers. In earlier decades, there were two fashion seasons. Now some designers change their lines six times a year, and retailers want to have almost continuous changes in their stock. In addition, fashion consciousness has now spread to a wider range of incomes.

The greater segmentation of markets and the faster changing of styles have shrunk the market for large production runs of identical garments. Industry analysts argue that commodity products such as men's underwear and socks that are sold all year account for only about twenty percent of the apparel market, and that this share is likely to fall. (For a discussion of this, see OTA, 1987, Chapter 2, p. 15, & the American Apparel Manufacturers Association [AAMA], 1988.) Moreover, even the most basic commodities now come in many more styles and colors than previously.

Every textile plant and all but one apparel plant studied for this project had over the last five years increased the number of styles and products that they were producing. In many cases, the number of styles was increased or the average production run was cut by a factor of ten. Even a mill producing denim, which has been the epitome of a standardized, basic commodity, had increased the number of styles produced at any one time from two or three to thirty. And studies of the retail industry confirm the proliferation of products available in the country's stores (Stanback, 1989).

The Accelerating Pace of Change

All the industries that we have studied are undergoing frantic innovation and technological change. This is all the more remarkable since banking, textiles, and apparel had enjoyed periods of stability during the 1950s, 1960s, and early 1970s. In the last decade, however, shifting international markets and sources of comparative advantage, fickle customers and clients, and rapid innovations in products and processes make one day's winner the next day's loser. This environment of change, as much as the actual characteristics of the new technology, new products, or new trade patterns, often forces fundamental changes in firm strategies. Traditional approaches geared to a more stable environment no longer work.

For example, most apparel and other soft goods are only being processed for a few hours, yet it often takes up to a year between an order and the arrival of the goods on the retail shelves. As long as styles changed infrequently, this was not a serious problem. But as mass markets began to break up and production needs became more difficult to predict, retailers found more frequently that they ran out of quick-selling items during the season (this is called a "stockout") and were stuck, at the end of the season, with large quantities of slower-selling goods that they were forced to mark down. Forced markdowns have increased by fifty percent during the last decade. Losses from stockouts amount to eight percent of sales (OTA, 1987, pp. 26-27). In 1984, the consulting firm, Kurt Salmon Associates, calculated "the opportunity cost from excessive markdowns, stockouts and excess inventories amounted to $25 billion a year, or twenty-three percent of the total retail value of all apparel sold in the United States at that time" (Harding, 1988).

One result of this increased uncertainty in an environment of intensified competition is that firms are placing increasing emphasis on reducing the time that it takes to develop, produce, and distribute a product. Improved communications and diffusion of technological information gives industry leaders less and less time to reap the benefits of leadership. On the other hand, in addition to its value in getting goods to market faster, reducing product cycle time also speeds the provision of services to customers, can save inventory interest and space costs, and allows firms to be more responsive to market shifts.

Real-time computer networks have allowed almost instantaneous delivery of many services such as travel reservations or insurance policy ratings. While the computer and its immediate access to information has allowed this to take place in the paper-shuffling

industries, product development time and production cycles are also dropping in manufacturing. The Japanese made the just-in-time inventory systems popular. Using just-in-time and other short-cycle systems, Toyota was able to cut its domestic sales, manufacturing, and distribution cycle time from four to six weeks in 1982 to eight days in 1987 (Stalk, 1988).

Similar strategies are now being implemented in the United States with great fanfare. Since the mid-1980s, as style changes in apparel and textiles have accelerated, leaders in those industries have turned from a virtual obsession with automation to an equally strong preoccupation with reducing the production and delivery times. This is called "Quick Response" in the industry. Quick Response will theoretically allow retailers to order with shorter lead times and to reorder hot items during the season. The efforts to implement Quick Response are taking place all up and down the supply chain including sophisticated links among computerized design; manufacturing of fiber, fabric, and apparel; marketing information; and retail level inventories. In some cases, these efforts have been able to cut lead times for garments from several months to six to ten weeks. Quick Response is now considered to be the domestic industry's greatest weapon (after tariffs and quotas) for fighting import competition (Gunston & Harding, 1987).

Concern is increasingly turning to the speed of innovation and the product development cycle. Innovators in financial services have been able to dominate, at least briefly, very profitable market segments in the financial services industry. Citibank's early innovations in consumer banking allowed it to develop a dominant position in some retail markets. Much has been made of the ability of Japanese firms to develop projects with significantly shorter lead times than firms in the United States. One survey found that Japanese automobile firms completed design projects in two-thirds the time with one-third the engineering hours of United States firms (Clark, Chew, & Fujimoto, 1987). One line of argument is that the United States takes a mass production approach to innovation. Rather than concentrating on incremental changes, United States firms have a tendency to focus on potential leaps in technology. This approach has been blamed for the loss of technological leadership in the production of air conditioners and of textile equipment (Stalk, 1988; Sabel, Herrigel, Kazis, & Deeg, 1987). The alternative is a more incremental approach to innovation with much greater integration into the production process itself. This incremental approach is much more immediately responsive to the continuous changes in markets.

Of course, it is possible that we are experiencing a one-time adjustment to a new type of technology. The problems associated with increased change and uncertainty and the emerging emphasis on the speed of innovation, production, and delivery will subside. However, given the continuing drop in the cost of hardware and software and the speed with which new products are introduced, it is difficult to believe that the economy is about to settle into a period of stable technology and markets.

Emerging Strategies

How are firms improving their ability to cope with increasing change and uncertainty and to produce a variety of products faster? The programmability and communications potential of computers seems to offer the technological basis for flexible, quick-turnaround production. Indeed, attempts to develop flexible and responsive systems all depend heavily on microelectronics.

Given this country's past success with mass production, the development and use of flexible technology in the United States is particularly difficult. For example, much of the impressive modernization in the textile industry and many of the advances in apparel production took place when industry leaders were still focused on a mass production strategy, and are often cost effective only for the production of large quantities of identical or similar items.

In the end, the flexibility potential of new technology can only be realized if it is accompanied by changes in firm organization and industry structure. I will discuss each of these.

Changes in Internal Firm Organization

Economists and organizational theorists have long debated the most efficient form of corporate organization. For large organizations, a fundamental goal of organizational design is to find a form that can take advantage of economies of scale in production, finance, and marketing, while avoiding the inflexibilities, cumbersome decision making, and lack of responsiveness to individual markets or clients that is inherent in large bureaucracies. In the last fifteen years, some analysts of business organization have concluded that

this combination of goals can be best achieved by the multidivisional corporate form (Chandler, 1977, 1982; Williamson, 1975, 1981). In this form, the divisions are organized on the basis of particular products or market regions, and they are run as quasi-independent profit centers responsible for marketing, product development, and production. The corporate directorate maintains overall financial control and allocation of global resources, serves in an advisory capacity, and is responsible for long-range strategic coherence. A key to the success of this type of organization is the decentralization of decision making to divisions with close and intimate ties to their markets. As markets become even more fragmented and regional, the logic of this strategy propels firms toward even more decentralization of at least some types of decision making.

Indeed, the spread of distributed data processing further enables this decentralization by giving divisions and departments access to centralized data and analytic capabilities. There has been a movement in this direction in banking. In the early 1970s, the United States banks studied gave very limited responsibilities to the branches. The latters' role was basically to service routine contacts with individual customers, which in any case involved only a very limited number of products and services. The branches did not have control over back office processing or loan approvals. In an effort to create better links to specific markets and customers, the current trend is toward the decentralization of loan, investment, and marketing decisions away from the headquarters to groups of branches. This has also been accompanied by an increase in responsibility of some of the individual branch employees. Rather than simply signing clients up for a limited number of services, these employees must now be able to help increasingly sophisticated clients choose from among a much larger portfolio of products.

In the textile and apparel industries there has also been a trend toward decentralization of organization and decision making within plants. These reorganizations have generally involved a movement away from a functionally oriented organization to one that is more oriented toward products or markets. For example, traditionally, shirt factories were divided into large departments that carried out particular functions—preparation of the cuffs or collars, cutting and sewing the buttonholes, sewing on the buttons, attaching the sleeves to the body of the shirt, and so forth. Orders moved through these factories in sequence. For example, if each of six orders took one week, then over five weeks would pass before some parts of each order came through. Advanced shirt factories are now more likely to be organized into larger numbers of smaller departments that can turn out the entire shirt. A

functional organization requires much more direction and coordination from the top plant management in order to establish priorities and to coordinate the movement of diverse products through each functional department.

With product-oriented departments, the department management has responsibility over all of the detailed production planning, and top management can treat the departments as semiautonomous product-creating units. This speeds up decision making and allows a more efficient product flow to the customer. This also opens the possibility for direct contact between customers and the actual departments in which the goods are being produced. For example, researchers from the OTA found one textile mill in which looms were reserved for a particular customer and representatives from that customer were frequently present in the department. However, this direct contact also requires more extensive diffusion of information about the operation of the firm, its markets, and customers.

The development of product-oriented organization has been accompanied by efforts to eliminate in-process inventories. Inventories in effect create buffers between the various steps in the production process. Problems that occur in one area do not immediately flow into other areas. The apparel industry carried this principle to an extreme. Each individual worker was buffered from other workers by several hours of in-process inventory. The reduction of these inventories transforms the production process, increasing the interdependence of individual workers and of the various steps in the process. The influence of machine failures and bad quality spreads much more quickly.

The use of teams is one approach to solving the problems caused by the elimination of buffer inventories. These strategies are spreading in the textile industry and even more so in apparel production. Delays resulting from individual problems can be solved by the group through mutual assistance or immediate reconfiguration of the work flow. This team-based approach accompanied by the reduction in in-process inventories has several advantages. First, direct labor savings and quality increases are often reported. Second, processing times for either manufactured goods or services can be sharply reduced. Third, the groups of workers tend to be more self-directed, thereby cutting down on the need for supervision. Fourth, this approach draws more initiative out of the workers themselves by getting them involved with improvements in the process.

United States firms in banking, textiles, and apparel are increasingly using more decentralization and team-based organizational forms. The United States banks in the study had increased branch decision making authority. To assess the spread of new production techniques, the AAMA (1989) conducted a survey of its members. In 1985, only one percent of the production workers in the firms that responded to the survey were being used in production processes designed to reduce in-process inventory and speed through-put times. By 1988, that share had risen to seven percent, and according to current plans, twenty percent would be used by the early 1990s (pp. 3-4). About half of the textile firms we studied had some form of work reorganization that was no more than a few years old.

These changes are now common in many other industries. Internal reorganization in the auto and other manufacturing industries has perhaps attracted the most attention, but changes within the service industries have been just as profound. For example, in 1987, the insurance company Aid Association for Lutherans (AAL) in Wisconsin transformed a traditional functional organization in which life insurance cases were handled by one department, health insurance by another, and billing and policy loans by a third. Now groups of twenty or thirty workers are assigned to work with field agents from a given region. The teams are able to carry out all of the one hundred and sixty-seven tasks formerly performed by the three functional departments, and the company has been able to cut processing time for some services from twenty to five days ("Work Teams," 1988).

Surveys indicate that between twenty-five and thirty-five percent of all United States firms and over forty-five percent of firms employing at least one thousand workers have experimented with quality circles or other forms of employee involvement or participation techniques. A 1982 study by the New York Stock Exchange reported that forty-four percent of the responding firms used some form of quality circle. Moreover, three-fourths of these efforts were less than two years old (Alper, Pfau, & Sirota, 1985; Kochan, Cutcher-Gershenfeld, & MacDuffie, 1989). Another study found that about fifty percent of unionized manufacturing firms had some type of joint participation scheme, most of which dated from the 1980s (Voos, 1987).

The actual impact of this type of reorganization has yet to be determined. Union representatives in the auto industry, where the team concept has been tried in many factories, argue that the team concept in that industry is little more than a sophisticated way to speed up work and weaken the union (Parker & Slaughter, 1988), although those in the

United Auto Workers opposed to the team concept have recently lost important elections. In the past, work organization experiments have rarely lasted more than four years (Griffin, 1988). Certainly, teamwork experiments tend to fail if they are implemented without other changes that make the organization more flexible and responsive (Kochan et al., 1989).

Past research on workplace experimentation may not be a good guide to current efforts. First, the surveys underestimate the level of activity, since there are many types of decentralizations and reorganizations that would not necessarily be identified as "teamwork" experiments. This is true of the work organization changes reported by Hirschorn (1988) in a bank, medical lab, insurance company, and a company that provides bibliographic references for scientific research, and by Zuboff (1988) in pulp mills and insurance companies. Moreover, judging by developments in the apparel and textile industries, data on work organization from the early or mid-1980s is already obsolete. Whereas in earlier periods, such as the 1970s, the popular interest was in quality circles or employee involvement (Kochan et al., 1989), the current interest in workplace reorganization and experimentation is closely associated with strategies to enhance competitiveness. The present interest is therefore more likely to be sustained.

Changes in Industrial Organization and Relationships between Suppliers and Customers

The needs of flexibility, quality, and speed have profound implications for the relationships among firms in the overall supply line for a product. If a producer is to be able to turn out a variety of goods quickly, without large inventories of supplies, that producer's suppliers must also be able to deliver high quality inputs just as quickly, whether they are manufactured items or services. One response to this problem has been vertical integration. This allows maximum control over all steps in the supply line.

A central problem with vertical integration, however, at least where substantial fixed or specialized capital, either human or physical, is involved, is that it makes flexibility much more difficult. A more flexible alternative to vertical integration involves the development of networks or partnerships among firms in the supply chain. One approach is for a large firm to spin off departments to serve as independent contractors. This is sometimes referred to as quasi-disintegration. And smaller firms in the supply chain, rather than maintaining arm's-length, market-mediated relationships to customer and supplier firms,

work out partnership arrangements in which they share information on demand and innovations and coordinate their production (see Jacquemin, 1988, pp. 150-151; see Johnston & Lawrence, 1988, for a discussion of how to develop close relationships with contractors without actually arranging them). A key to this strategy is close cooperation among the firms within the network. If this is successful, each firm can enjoy the advantages of a coordinated and responsive supply pipeline while concentrating on its function within that process, without being assailed with the problems of capacity utilization and balance that plague larger, vertically integrated organizations.

The apparel/textile complex offers a particularly dramatic example of this development. Some analysts have attributed the success of some sectors of these industries in Japan and Italy to their use of producer networks (Dore, 1986; Piore & Sabel, 1984). In the last three or four years, in the United States, large apparel and textile employers have tried to develop closer relationships to suppliers and customers. These relationships now include computerized links to facilitate ordering and minimize inventory. In general, whether through backward or forward integration or through the development of subcontracting partnerships, the traditional vertical structure of the textile/apparel complex is blurring. More and more, large department store chains are deeply involved with apparel and soft goods production, while garment producers themselves have moved into direct retailing, Benetton being the best-known example. Whatever the particular institutional form, there is now much more interaction among firms (or departments and divisions in the case of integrated operations) up and down the supply chain. One important implication is that more employees within each firm or division will interact with employees in other firms or divisions. Closer links between firms at different levels of the supply chain also require greater understanding within each firm of the problems and objectives of other firms in the network.

The problem of vertical integration versus network in the structure of the industry has its analogy in the relationships between employers and employees. Given the increasing uncertainty and change, firms want to maintain flexibility and are therefore reluctant to make long-term commitments to individuals. Many firms have turned increasingly to temporary or contract workers. Abraham (1988) refers to the relationship to temporary workers as "market-mediated" relationships. But just as the relationship between subcontractors and contractors is much closer than an arm's length market relationship would imply,

temporary workers, especially those higher up in the employment hierarchy, could have close and long-lasting interactions with the firms that hire them.

Conclusion

It would be an error to argue that at this point all firms or even the large majority of firms are responding to the changes that confront them by implementing these types of technological and organizational changes. However, the empirical measures that are available and the logic of the underlying economic forces suggest that this type of work reform and innovation is spreading.

I have emphasized that the drive for more flexibility and a greater emphasis on continuous innovation and fast response to market shifts has led to a variety of strategies on the part of firms. Investments in new technology are crucial, but firms have also learned that the flexibility and productivity potential of new technology cannot be attained without other changes. These changes involve a more market and product oriented internal firm organization and closer interactions among firms in the supply chain. A central effect of these trends is to create a much denser and more tightly packed production system. Lead times, buffer inventories, and other types of slack and margins for error and relaxation are all, at least in principle, being squeezed out of the production system. Firms and workers are now involved in more integrated and interdependent networks in which, in many cases, there is greater autonomy at lower levels and decentralization of decision making. This juxtaposition of interdependence and autonomy and its attendant technological and organizational developments can potentially have a strong influence on skill needs and human resource strategies, including training provided by the firm. We turn to these issues in the next section.

SKILLS AND SKILL FORMATION

This section discusses the skill and educational implications of the technological and market changes and the responses of firms to those changes. I first discuss the nature of skills and then turn to the changing role of the educational system and the workplace in preparing the country's workforce.

Skills and Education

The increase in uncertainty and in the pace of technological and market change is a fundamental characteristic of today's economy. A well-established body of research associates education with the ability to cope with change. Schultz (1975) argued fifteen years ago that education improved a worker's ability to deal with "disequilibria." Other research shows that industries experiencing faster technological change tend to employ workers with higher levels of educational attainment (Bartel & Lichtenberg, 1987).

If educated workers are better able to respond to change and uncertainty and if uncertainty is growing, then the relative demand for educated workers should also be growing. This, indeed, appears to be taking place. While the difference in earnings between high school and college graduates fell during the early 1970s, it has been growing in the 1980s. In 1979, college graduates with one to five years of experience earned just over thirty percent more than high school graduates with similar experience. The average earnings differential for all experience levels was about fifty percent. By 1985, the differential for recent hires and for all experience levels had risen to about sixty-five percent (Murphy & Welch, 1989, p. 19). This dramatic change in wage differentials presents a fundamental challenge to the overeducation argument. If the premium that employers are willing to pay for educated workers has risen, it is difficult to argue that the education has little relationship to work.

The growing importance of education and skills was also evident in all of the four industries that were the focus of the present study. Despite the many sharp differences among the industries, several common trends in skill needs did emerge. The similarities were strongest among apparel, textiles, and banking. The business service industries that were studied were overwhelmingly dominated by higher level professional and technical

personnel, while the other three industries continue to have large numbers of middle and lower level workers.

Shifts in overall skill requirements emerge from two sources. One involves changes in the relative number of high- and low-skilled positions (changes in the occupational distribution); the other involves changes in the skills required for given occupations.

In the study industries, current market changes and new technology have shifted the occupational structure toward higher skilled jobs. For example, in the financial service sector in the United States, managers, professionals, and sales workers accounted for forty-seven percent of employment in 1971 and fifty-two percent in 1985. Automatic teller machines and computerization of back office functions have eliminated many of the lowest level clerical and teller positions in banking. In the textile industry, there were 4.2 operatives, laborers, and service workers for every craft and technical worker in 1975, but by 1985, this ratio had fallen to 3.5 to 1. In apparel, the ratio of repair technicians to operators has grown, although operator positions continue to account for the overwhelming majority of nonmanagerial jobs in the industry. For example, in the 1970s, there had been approximately twelve sewing machine mechanics for 2400 operators at one apparel firm. In 1988, there were forty mechanics for 1200 operators.

Some of this shift comes from the elimination of lower level jobs. Increasing computerization is leading to the elimination of a considerable amount of repetitive, routine, manual processing work that in the past supported the production of banking services. The handling of printed forms, paper-based files, manual records, manual calculations, and similar tasks had been the basis of many banking jobs. This transformation is affecting all workers, although its most direct impact is on low level personnel (file clerks, messengers, low level statistical clerks, and similar personnel) by eliminating their *raison d'etre* and shifting their functions to middle level personnel working with automated systems. Accounting software has reduced much of the routine work needed for bookkeeping and accounting. In textile plants, many of the jobs that involved loading and unloading material from machines and moving material around the plant have been eliminated. Although there remain profound barriers to the automation of lower level jobs in apparel, modern sewing machines have been able to eliminate some routine jobs such as trimming threads on completed garments, and advanced production processes are beginning to reduce the need for workers to move material from operator to operator.

A similar picture emerges from national occupational statistics. Between 1976 and 1988, the major occupational groups that had workers with above average educational levels were also those that grew at a faster rate than the overall economy. For example, executive, managerial, professional, technical, and marketing occupations all grew faster than the 29.5% overall growth rate. In addition, the share of each of these occupations accounted for by workers with some college also exceeded the forty-four percent share for the economy as a whole. All of the other major occupational categories, including service workers, both grew more slowly than average and had lower educational levels than the overall economy. Projections to the year 2000 repeat this pattern. In general, those occupations now filled by workers with higher levels of education are also those projected to grow at a faster than average rate. Assuming that the educational distribution of each occupation remains the same, 51.8% of the jobs that are projected to be created between 1988 and 2000 will be filled with workers with some college education, while in 1988 only 42.5% of the workers had at least that much education. (The relationships between educational levels and occupational growth are discussed in detail in the Appendix.)

The analysis of the occupational distribution, however, is an incomplete method of studying changes in skills. Many of the most important and interesting changes are taking place within occupational categories. It is useful to think of occupational changes as arising from two sources. The first involves the direct technical needs of new technology or procedures. The second involves changes called for by innovations in organization or production processes that may or may not be accompanied by new technology. This distinction highlights the contrast, developed earlier, between a focus on the tasks required by the new technology and a more holistic view of the ways in which technology and other changes are influencing work as it is actually carried out.

The Direct Effects of New Technology

Although I have emphasized that there is not necessarily a direct or simple relationship between new technology and skills, there were circumstances in the industries cited in which more advanced equipment or more modern procedures did call for workers with more advanced skills. In textiles and apparel, the increasing need for technical skills is particularly acute among repair and maintenance personnel. Some analysts have argued

that computerized equipment can be easier to repair since it can sometimes diagnose its own problems. There was no evidence of this in these two manufacturing industries.

The traditional semiliterate workforce available for internal promotion is no longer adequate. Employers are increasingly trying to hire technicians with two-year associate degrees, and sending their current workers out to the local community colleges for upgrading. Often the major problem with this upgrading strategy is simply that the available workforce does not have the basic literacy skills to complete the necessary technical training. One apparel maker who was opening a completely new factory with modern equipment was training twenty new mechanics to maintain the machinery, but he stated that he was spending more on teaching them to read and to be competent at basic math than on the actual technical training.

In banking, there is a growing need among upper tier workers for high level, specialized knowledge such as systems analysis, market research, mergers and acquisitions, and management. This is particularly true for high level professionals who are involved in the development of new products and new business relationships. In many of these areas, the complexity of the services offered requires that they be developed and delivered by highly specialized professionals.

At the same time, an analysis of some of the tasks carried out especially by machine operators in textile and apparel factories does suggest that some activities have been deskilled. In apparel manufacturing, some automatic machines that carry out particular steps such as pocket setting allow managers to replace skilled workers with machine tenders. Modern looms and spinning machines reduce the need for some reasonably skilled manual tasks such as joining together the ends of broken yarn. Until as late as the early 1980s, most apparel manufacturers consciously pursued a strategy of reducing the skill requirements for many tasks. But a task-by-task analysis obscures the effect of work reorganization. Concluding that a task is easier than it was before is not a valid comparison if the task has been combined with other tasks as a result of changes in work design. Indeed, the studies in this report suggest that despite the simplification of some tasks, work design changes in these industries have increased the intellectual and skill demands on the workforce. For example, the growing number of apparel makers who are trying to produce a greater variety of goods with faster throughput times are moving away from the deskilling strategy that they pursued only a few years ago.

The Effects of Organizational Change and Work Reform

Changes in organization and work, as opposed to straightforward changes in technology or procedures, have a variety of implications for skills and competencies. I will discuss them in three broad categories. The first involves changes in skills called for by the need to operate in a more uncertain and less well-defined environment; the second consists of increased ability to manage greater and more complex interactions with other individuals; and the third involves the skills needed to supervise, manage, and lead in the new environment.

The Skill Implications of a More Uncertain and Less Well-Defined Environment

A widespread effect of current changes in production processes in apparel and textile firms is the increase in the number of tasks required of each worker. Functions such as changing cloth on looms were previously carried out by groups of workers, each of whom was assigned a particular task. Increasingly, this function is carried out by teams in which each member is capable of carrying out several or all of the required tasks. Production process innovation in the apparel industry is also combining many previously separated tasks. Team-based organization especially linked to the elimination of buffer inventories is more effective if workers have a wider range of skills. The shift from functional departments to product-oriented departments makes it more difficult for mechanics to specialize in one machine, therefore requiring workers to attain a broader set of skills.

As a result of increased production variety, and the pace of product as well as technological change, it is more difficult, and less efficient, to plan out every contingency that an employee must face. Furthermore, the increases in time pressure and the reduction in buffer inventories make it more problematic for employees to refer problems to specialized departments or to await instruction or permission from superiors. The reduction in inventories and the emphasis on speed make prevention of equipment failure more important.

The particular skills required for this new environment are difficult to define, but it is necessary to understand the broader system in which the employee is involved, and to have a more abstract and broader understanding of the technologies, the operations, and, in some cases, the markets and customers of the firm. A good basic education is increasingly important. In the sample of apparel firms studied for this project, there was a strong

relationship between concern about improving the educational and skill level of the workforce and attempts to implement modern technology or innovative production processes. In the last two years there has been an accelerating interest by employers in the textile industry in programs to strengthen basic literacy, numeracy, and written and oral communication.

There are many similar developments in banking. Middle level personnel are taking on a broader array of functions. Increasing computerization of banking products is bringing together information once scattered among various employees and departments. As a result, many middle level jobs traditionally oriented toward "order taking"—filling out forms to initiate the clerical production process—increasingly involve "serving"—providing customers with the various pieces of information necessary to offer the customized mix of services that will best answer their needs. Therefore, many of the responsibilities associated with managing the interaction with customers are filtering down from upper tier to middle tier personnel. For example, a corporate account officer may now delegate much of the day-to-day interaction with corporate customers (e.g., money transfers and issuance of letters of credit) to a subordinate corporate service representative. One result of these changes is a shift toward finding better educated middle level workers who have a stronger capacity to comprehend both the bank's services and capabilities and the customer's needs, and a shift away from lesser educated clerks who worked primarily on specialized form-handling tasks. The best example of this in business services is perhaps the effect of accounting software. The latter has freed accountants from much of the routine work that they previously carried out, and has changed their role to one in which they act more as consultants capitalizing on their intimate knowledge of the client's finances.

Increased Ability to Manage Greater and More Complex Interactions with Other Individuals

In all of these industries, the requirement is for employees to have both an ability to manage more complex interactions within the firm, and to manage interactions between the firm and individuals from customer/supplier firms and end-use customers. A fundamental characteristic of denser, more compact production systems is the reduction or elimination of the separations and to manage interactions between individuals within firms and between firms at different places in the supply chain. The separations have traditionally been created by long lead times, slow communications, bureaucratic procedures, and buffer inventories.

The elimination of separations will create greater direct interdependence among individual workers—the actions of any individual will have a much more immediate effect on others.

Some of the firm reorganization that is taking place now in business and financial services, and in apparel and textiles as well, will also create greater personal interaction among workers. Team-based work organization succeeds or fails on the basis of the nature of the interactions among the team members. There is also the potential for greater interaction among individuals in the various firms at lower levels of the job structure in the more complex relationships to suppliers and clients. In the service industries, social skills are critical since the services provided in effect come about only through the personal interactions between employees of the firms and the clients. Business service firms are, therefore, putting increasing emphasis on salesmanship and customer service skills.

New Supervisory and Managerial Skills

The success of many attempts to introduce new technology on work and firm reorganization often depends on the ability of higher level personnel to manage the change. Indeed the change will not even be attempted unless the management is convinced of its need. There are many examples in traditional industries such as apparel and textiles in which one forward-looking manager must convince many of his colleagues that something must be done. Managing a more complex and interactive production requires new sets of skills. Supervisors now need not only the capacity to manage, but the ability to set strategic goals, to share information with subordinates, and to listen to them. In the past, the role of middle managers was to take orders and pass them down through the hierarchy.

Changing industry structure that creates the need for more interaction between employees and representatives from other firms will affect the jobs of higher level personnel most directly. Moreover, it is particularly important that these employees be involved in ongoing process and product innovation, rather than simply acting as agents for higher level managers.

The increasing pace of technological and market change underlies many of these new demands on workers. Firms that expected to make only a narrow range of products with the same equipment for several years could make do with low-skilled workers who had little conceptual understanding of what they were doing, even if the machines were highly sophisticated. The problem involves the interaction of the technology with the

changing environment in which the firms operate. The manager of technical personnel in a large apparel plant, in complaining about the repair personnel, stated, "These workers can't do a damn thing that they haven't done before, and my equipment is changing too fast to allow me to show them how to do everything."

The Changing Role of the Workplace and the School in Preparing the Nation's Workforce

The controversy about changing skill requirements is often focused on the need for schooling. One of the central points of the current school reform movement is that there are fewer jobs for individuals with lower levels of educational attainment. Analysis of the occupational data shows that occupations now held by individuals with higher educational levels are growing faster than occupations composed of those with less education. Nevertheless, a great deal of education and training occurs at the workplace. Indeed, the cost of training on the job exceeds expenditures on postsecondary education and may approach those on primary and secondary education.[3]

How has the technological and market restructuring that has taken place in the last fifteen years affected the role of training, both at the workplace and in the educational system, in preparing the country's workforce? Even if more skills are needed, it is possible that schools could provide all of the necessary additional education, thus requiring no additional training on the part of the firm. In order to analyze the effects of current economic restructuring on firm-based training, it is necessary to take account of the different types of training that firms provide.

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[3]*Training Magazine* estimated that firms with one hundred or more employees spent about $40 billion annually on formal training programs (Feuer, 1988). And this is a gross underestimate. The large majority of these expenditures were for the salaries of trainers, little account being taken of the opportunity costs of the time spent by the trainees. Moreover, the numbers neither include an amount for small firms nor for informal training, which some experts believe may be as high as $180 billion (Carnevale & Gainer, 1989, p. 15). Although the precision of these estimates is very much open to question, there is little doubt that expenditures by employing institutions on education in 1988 exceeded the $125 billion spent that year on public and private postsecondary education and may be close to the $185 billion spent on primary and secondary schooling (U.S. Department of Education, 1988, Table 24).

For example, they can provide training that workers need to move to a higher level position—training for upgrading. Firms also provide training of a general nature such as literacy or general technical skills, that normally could be learned in school, when they cannot find workers with those skills in the labor market. Another type of firm-based training is used as a response to change—when new technologies, work processes, or products are introduced, workers must be taught to deal with them. But training can also be used as part of a strategy to increase the responsiveness of the firm. There is a subtle but important distinction between these last two types of training. One involves a reaction to change, possibly without changing the organizational structure of the firm, while the other is part of a strategy to create a more responsive and flexible organization. Current restructuring in the industries studied has increased some of these types of training while decreasing others.

A variety of recent developments suggests that firms are trying to move away from training for upgrading. In the past several decades, many large firms maintained the practice of hiring young workers with few skills for entry-level positions, and moving them into higher level positions as they aged and gained experience. This type of mobility, based on internal promotion, was seen as a defining characteristic of good working-class jobs—primary sector jobs in terms of segmented labor market theory—which provided opportunities for occupational mobility through the "internal labor market."

Among the industries covered in our case studies, banks and textile firms relied heavily on internal promotions at the lower end of the employment hierarchy. Apparel firms did as well, although for most workers, the job ladder was short since the overwhelming majority of factory-based employees were sewing machine operators. Nevertheless, internal job ladders did lead to skilled jobs such as cutters, supervisors, and sewing machine mechanics (cutters and mechanics are traditionally male jobs while the sewing machine operators are women). Traditionally, accounting firms had strong internal labor markets in which junior accountants, usually with college degrees, were hired in entry-level positions, and later moved up to higher levels and eventually to partnerships.

Over the last fifteen years, a variety of factors have threatened the strength of internal labor markets and many firms appear to have moved away from strict internal promotion policies. Instead of hiring most workers at low level ports of entry and filling higher positions from within, many firms have begun to increase the number of ports of entry.

These ports of entry have been increasingly based on educational credentials. To the extent that this is true, it has signaled a reduction in the opportunities available for high school dropouts and even for those who have high school degrees but no more.

The case studies suggest that there is great pressure on the traditional internal promotion systems in these industries. Banks generally have established separate ports of entry for high school graduates and graduates of two-year postsecondary institutions. At higher levels, generalist managers who had been promoted from within the firm are giving way to technical specialists hired directly from the outside. While this has often threatened the firm culture, the banks have seemed to be able to carry out this strategy.

For textile and apparel firms, the pressures to change the system of internal promotion involve the new skills needed for technical machine repair and maintenance jobs. While in the past, mechanics and supervisors were almost always promoted from operators or other lower level workers, firms in these industries increasingly want to hire graduates of two-year postsecondary programs for these positions.

Accounting firms have also begun to move away from their reliance on internal promotion. Perhaps the most important reason is that technology has tended to reduce the need for junior-level accountants who previously carried out much of the routine work. As a result, the pyramid structure of the firms has narrowed, reducing the pool of junior professionals from which to draw for promotions. In some cases, changes in markets and client needs have sometimes been so rapid that the internal system has been unable to provide the required specialized expertise.

These examples from the apparel, textile, banking, and accounting industries suggest that in some cases, firms would like to break up some of their internal labor markets. This seems to reflect requirements for higher basic education at many levels of the firm. Now, more than in the past, there is a body of specific basic technical knowledge that is needed and that is of sufficient quantity, that firms would prefer to hire personnel who already have that knowledge. Alternatively, the depletion of the ranks of lower level employees reduces the pool of potential internal recruits.

Still, the fate of internal labor markets has not been sealed. Substantial internal promotion continues to occur. Although conceptually we can separate training for

upgrading from the other three types of training outlined earlier, in practice any given program of training will serve more than one purpose. And even if firms might prefer to weaken their internal labor markets, current economic restructuring, as we shall see, creates incentives for firms to increase those other types of training.

Among the four study industries, textile firms and some of the more progressive apparel firms were increasing their involvement in teaching basic literacy and written and oral communication or generic sewing or mechanic skills. In many cases, firms are unable to find these skills among their current workers or in the labor market. For example, while textile and some apparel managers would have liked to hire mechanics with some postsecondary training, they were often unable to locate such recruits. In the South, students who were enrolled in postsecondary institutions were not interested in working in a mill or a sewing plant. Most firms now fill these positions by providing supplemental training, often at local community colleges, to lower level employees. As requirements for literacy rose in the textile industry, firms were faced with a choice between providing additional training to their current employees or replacing them. In many cases firms prefer to retrain their current workforce. Moreover, in some cases, especially in the rural South, these firms would not be able to find a replacement labor force with good basic skills even if they were inclined to look. Thus, basic skills programs in the textile industry have proliferated in the last few years. For example, almost thirty percent of the federally funded workplace literacy programs in North Carolina are in textile mills (North Carolina Department of Community Colleges, 1989). A conference on basic education programs given by the American Textile Manufacturers Institute in June 1989 attracted representatives from one-half of the Institute's member companies.

Training as a response to technological change is also important. If change accelerates, firms will have to provide more of the instruction necessary to allow their employees to work with new technologies of work processes. Furthermore, employees in industries experiencing faster technological change also receive more employer-sponsored training (Tan, 1989). For example, in the textile and apparel industries, this type of instruction was often carried out by the equipment supplier, in the case of new machinery, or by a consultant, when the change involved a new work process. Given more frequent retraining, employers become more concerned about whether their workforce has the basic educational level that helps them benefit from the additional training. If workers cannot read, then it is obviously much more difficult to teach them. According to Tan, analysis of data

on individuals indicates that outside education and firm-based training are complementary—individuals with more education tend to receive more training on the job. Apparently, workers with more education are easier to teach. Therefore, the increasing need for retraining is one important reason why firms may want entry-level workers with higher levels of educational attainment than previously.

Nevertheless, given adequate basic education, teaching the tasks required by new technology was seen as a manageable problem. This was especially true in the banks. Perhaps the difference between the banks and the manufacturing firms was that at least the banks that were studied did not have to depend on large numbers of workers who were semiliterate.

Firm-based training is not simply a method of responding to change, but can also be used to help turn the firm into a more responsive organization. In both the service and manufacturing industries, firms are increasingly trying to focus more on innovation, customer service, and fast response to market changes. In order to do this, they are using more teamwork, decentralizing decision making, and building more complex ties with customers and suppliers. Production processes with these characteristics must rely on employees who know the markets and customers, who know the capabilities of the firm, and who can work together with a wider range of employees as well as representatives and employees of other firms. Much of this type of knowledge and capability must be learned in the firm. Even if employees are hired with appropriate skills or knowledge, they must now be able to apply these skills within the particular internal and external environment of the firm. Many firms in these industries, in addition to offering training in basic skills, technical skills, and advanced expertise, also provided training to a wide range of employees in areas such as knowledge of the firm's products, markets, and goals; communications and teamwork skills; and improved interactions with customers and clients.

In an economy that puts an increasing premium on innovation in both products and production processes, firm-based training and education (or at least training closely coordinated with the firm) has an additional advantage. The process of innovation can increasingly be integrated with training. The training provided to teach workers about a new work process can also be used to determine how that process might best be applied to the firm's particular needs. Or seminars given to discuss products can be used to develop

new products or to generate ideas about how changes in the products might improve the process used to produce them.

Among the industries that we studied, the financial and business services were more advanced in many of these areas of firm-based training than the manufacturing firms. Certainly, there remain small apparel firms that offer only the most immediately necessary training. And managers, salespersons, and other higher level employees receive more training than clerical workers or machine operators. Nevertheless, on average, firm-based training was increasing in all of the industries and at all levels. Even in the tradition-bound apparel industry, we found some firms that had purchased videotape instructional programs for teamwork skills for their operators and had conducted seminars to bring together operators, mechanics, and supervisors so that they could better understand each other's jobs.

Even if firms have in some cases weakened traditional internal labor markets, the current changes in technology and markets have created incentives for firms to increase their efforts to provide the other types of training outlined above. It is not a paradox that firms are both relying more on the outside educational system to prepare workers for various levels of their employment hierarchy, and at the same time, increasing their commitment of firm-based training. It should also be emphasized that the institutional distinction between the outside education system and firm-based training is increasingly blurred. According to a U.S. Census Bureau (1987) survey, about thirty-one percent of formal firm sponsored training is carried out in outside educational institutions.

To be sure, there is little reliable information or data on firm-based training. Although there is a thirty year tradition of the theoretical analysis of on-the-job training, the empirical study of training carried out by the firm is only in its infancy. Moreover, although the use of training to create more flexible organizations is growing, how to pursue this goal is still not well understood and it is pursued explicitly by only a minority of firms. It is still easier to view training as an activity needed to teach workers the skills needed to carry out particular tasks.

Even so, firms are beginning to move away from this view. An increasing number understand that training and retraining of the experienced workforce is a key to the development of a flexible and responsive organization. As the economy changes, putting a greater premium on the ability of firms to innovate and adapt, the role and importance of

employer-sponsored training, carried out both inside the firm and through educational institutions, will also grow.

CONCLUSION

This section first returns to the controversies outlined in the second section in light of the findings of this paper. I then consider the extent to which this argument, which is based primarily on four case studies, can be generalized. The section ends with a discussion of policy directions.

The Skills Controversy Revisited

A fundamental weakness of the discussion about skills and technology is that it has often been conceptualized in narrow and ahistorical terms. In light of the discussion developed in the previous sections of this paper, we can now look back on some of these arguments and see the implications of a broader and more historically specific examination of the relationships between skills and technology.

According to Braverman (1974), technology was used by capitalists in such a way as to maximize their control over the work process. Levin (1987) used more standard economic theories of the firm to make much the same argument—work was simplified in order to facilitate the supervision of workers who were prone to shirk. More recent research has emphasized that there is a tradeoff between control on the one hand and flexibility and innovation on the other. Contrary to the hopes of some managers and analysts, microelectronics has been unable to eliminate this tradeoff by embodying the flexibility in the machines rather than the workforce. In order to have a flexible and responsive organization, it still remains necessary to have a flexible and responsive workforce. Moreover, developments in the last twenty years have changed the terms of the tradeoff between control and flexibility. The Braverman and Levin arguments may apply to an earlier era, but employers who continue to focus primarily on control pay an increasing cost in the market.

The stage or life-cycle theories developed by Bright (1958) and later by Flynn (1988) imply that skill needs moderate as technologies mature. This perspective does take account of changes over time, but views history as a repetition of cycles, neglecting secular trends. If change is more endemic and technological change and innovation are more continuous, then technologies or work processes will have less time to mature and to settle into well-known and well-understood patterns.

The argument developed in this paper also reveals where some of the earlier modernists writing in the 1950s and 1960s erred. For example, writing in the 1950s, Walker (1958) imagined new skills that sound like the types of skills progressive employers are calling for today. The problem with Walker's analysis was that it focused too narrowly on technology. Under much more stable conditions, as it was then, new technology has an ambiguous effect. Those conditions under which new technology led to higher skills exist much more now than they did in the 1950s.

The errors in Bell's (1973) analysis reveal the most about how our understanding of the interactions among technology, society, and the economy have changed in the last twenty years. Bell understood the acceleration of the pace of change and the increasing importance of technology and science; nevertheless, in many ways, his view of how society would adapt to these developments is more consistent with the era of industrial mass production than it is with what we view today as the post-industrial economy.

The subtitle of Bell's book, "A Venture in Social Forecasting," is rarely mentioned, but the increasing sophistication of econometric forecasting had much impressed him. The central argument of his book was that advances in the theoretical codification of knowledge and technological development, especially the mainframe computer, would allow increasingly accurate forecasts of macro-economic movements, demand, and even of technological changes.

Bell (1973) makes a rather remarkable statement in his introduction:

> The goal of the new industrial technology is, neither more nor less, to realize a social alchemist's dream: the dream of "ordering" the mass society. In this society today, millions of people make billions of decisions about what to buy, how many children to have, whom to vote for, what job to take, and the like. Any single choice may be as unpredictable as the quantum atom responding erratically to the measurement instrument, yet aggregate patterns

> could be charted as neatly as the geometer triangulates the height of the horizon. If the computer is the tool, then decision theory is the master. (p. 33)

He goes on to point out that Schumpeter had conceptualized technology as an "open sea," and he argues that

> one of the problems of the post-industrial society would be the need to iron out the indeterminancy of the future by means of charting the open sea. The various efforts at technological forecast in the 1960s argued the feasibility of this proposition. (p. 33)

Looked at from the present and adding the perspective that one of the main characteristics of industrial society was its use of mass production, Bell's argument appears to be an effort to hold on to the mass production paradigm. Mass production derived its impressive productivity gains from capital intensive production based on economies of scale. Predictability was essential. For Bell, forecasting would allow the continuation of a production system based on predictability in an economy and society characterized by accelerating change.

Bell conceived of the university, where the theory and technology for making the forecasts would be created, as the "primary institution of the post-industrial" society. This conception is indicative of another fundamental characteristic of a mass production paradigm—the separation from production of innovation, planning, research, and learning. The universities and research labs would originate the forecasts that would allow the production system to maximize its productivity potential. This was not so far from Braverman's (1974) view; both he and Bell expected that much of the mental work would take place away from the factories and offices where goods and services were actually produced. The difference between them was that Bell seemed to think that technology could eliminate almost all manual and lower level work.

What is wrong with Bell's view? Of course, despite reductions, manual and lower level jobs continue to exist. But Bell's views on the role that microelectronics can play in coping with greater change and uncertainty have been proved erroneous. Certainly computers and theoretical developments have improved forecasting abilities, but expectations about their accuracy began to plummet soon after Bell's book was published in 1973. The computer has not given us a certain view of the future through sophisticated forecasting. Ironically, what it has done (linked to new ways of managing and working with people—another crucial issue not emphasized by Bell) has been to reduce the *need* for forecasts.

It has had this effect both through increasing the quantity and timeliness of information and through promoting developments in the processes of innovation, design, production, and distribution that reduce necessary lead times.

Bell wrote from a perspective in which technology could be used to make the world predictable. The higher skills and, indeed, increasing employment would occur in the universities and research institutions where those predictions were to be made. But instead, new technology, linked to innovations in work organization and human resource management, has been used to adapt to the unpredictability of the world. This has also required a closer integration between innovation and production, so it has not been the universities that have emerged as the society's primary institutions, and higher skills are needed much closer to the point where goods and services are produced. Rather than an intellectual "clerisy" directing fully automated production processes, as Bell predicted, or a corps of elite managers and technicians marshalling an army of deskilled machine tenders, as Braverman foresaw, the production system has evolved into one that calls for more mental engagement of workers at all levels of the employment hierarchy.

Are the Results General?

Research on the changing nature of work and skills has been caught between broad-based data that fails to reveal much about the most interesting and probably important developments that are taking place and more revealing case studies that can be dismissed as unrepresentative. The four industries in the study—apparel and textile manufacturing and financial and business services—were chosen to represent a range of industries including capital and labor intensive manufacturing, a service industry that traditionally employs large numbers of lower and middle level workers, and one dominated by higher level professional and managerial personnel. In the manufacturing industries, both progressive and more traditional firms were chosen. In the service industries, the progressive or leading firms were chosen. The emphasis on forward-looking firms resulted from our interest in trying to understand the direction in which the industries were moving rather than in getting a static picture of the current situation. Moreover, the conclusions are not based only on a myopic analysis of the study firms since we drew on information from a variety of sources and relied on extensive contact with owners, consultants, union representatives, and educators associated with the industries.

Despite the diversity of the study industries, the basic trends outlined above were common to all four. To be sure, each industry has particular problems and preoccupations. Business service firms have trouble recruiting adequate numbers of specialized higher level personnel, especially in the fast-growing computer systems fields. Apparel and textile firms still need large numbers of relatively low-wage workers. In many traditional apparel and textile regions, it is increasingly difficult to recruit workers willing to work in factories for low wages. The service industries, not surprisingly, have a much greater preoccupation with the ability of their employees to interact with customers.

Nevertheless, the broad trends are shared by both the manufacturing and service industries. Although the distinctions remain between those industries that have traditionally emphasized mass production and those that produced more varied and customized goods, all the industries are very much preoccupied with increasing their flexibility and responsiveness to customers.

To be sure, these four industries, despite their diversity, cannot represent every possibility. Another way to look at the generalizing problem is to consider the factors that I have identified as the primary determinants of the changing characteristics of work—microelectronics, the intensification of competition, changes in the nature of demand, and the accelerated pace of technological and market change. Therefore, if the argument is valid for the study industries, then it should also apply to the many industries that share these characteristics. At the same time, industries or firms that differ along these dimensions can also be expected to follow a different human resource trajectory. For example, given the increasing importance of competition, this focus raises questions about the production of those goods or services that have more tenuous or complicated links with the market such as health and public sector services. In the vast case study literature on skills and technology, these types of sectors have received almost no attention (see OTA, 1988; Stanback, 1987). Clearly they are affected by technology and changing consumption patterns; nevertheless, not only is our knowledge about actual developments more limited, but the motivating factors behind them are more obscure. Thus, systematic analyses of sectors or industries that differ according to the central factors identified here must be undertaken in order to strengthen the generality of the argument.

Policy Directions

This project set out to evaluate the educational implications of current changes in technology and in the structure of the economy. It is important, however, not to view the relevant policy issues strictly in educational terms. A broader underlying goal of this project was to understand what role public policy can play in enhancing the productivity and well-being of the country as a whole, in promoting equity in general, and in strengthening the employment and economic opportunities of the poor and disadvantaged. The current economic restructuring presents some opportunities and some barriers for achieving those broad goals. If the economy has not so far reached its productive potential, given the resources that it has available, some of the reasons certainly involve deficiencies in the educational system. Nevertheless, correcting those problems—that is, providing the optimal mix of skills of individuals leaving schools—does not guarantee that as a society we will be any closer to the broader goals that we pursue. Even if we have the best mix of skills, they must also be used optimally. Certainly it would be possible to enter almost any workplace and find potential improvements in the ways that the skills of the current workforce are used. This is why I have emphasized changes in the innovations in the division of labor within the firm, in interactions among firms, as well as in education at the workplace. Strengthened schools without improvements in all of these areas are unlikely to have a large impact.

Perhaps the most important accomplishment of educational reform would be to convince managers that their firms will benefit from a reorientation of their human resource and training policies. The research reported here does suggest that now, more than in the past, some desirable social goals such as effective universal basic education and work enrichment at lower levels of the occupational hierarchy are also in the interest of the country's firms. A clear role for social policy here involves supporting research, pilot projects, and dissemination so that the best approaches to these problems are better understood and so that the information reaches the broadest possible audience. We found promising examples of regional centers for innovation and information diffusion set up, either in existing schools and colleges or through specialized organizations. These are particularly important for reaching small firms.

That being said, direct reform of the public educational systems and of internal training strategies must also play a role. The case studies did turn up examples of situations in which firms were thwarted by the quality of the available workforce in their efforts to introduce various organizational and strategic innovations. In the rest of this section I outline some broad educational policy directions that emerge from our research program.

It is difficult to argue with the goal of universal secondary school education. The nation's economy is paying an increasing price for the failure of its schools to provide universal education in basic skills such as literacy, numeracy, and written and oral communication. I have also emphasized throughout this report the relationship between more education and the ability of individuals to react to change and uncertainty and to benefit from firm-based education.

Nevertheless, it is not clear that the types of general skills that have been identified as increasingly important are well taught in educational institutions, especially many of those institutions that are not in elite middle-class communities. Progressive firms want workers who have the ability to apply general knowledge and principles for solving problems in particular situations. Moreover, the increased emphasis on teamwork and more complex interactions with coworkers, customers, and suppliers also calls for different types of social skills. Thus, to the extent that schools emphasize rote learning on an individual rather than a social basis, they may not be doing a good job in preparing their students for the workplace. There is a growing interest in teaching problem solving skills and more conceptual learning in schools, but much remains to be learned (Resnick, 1987a). There is also an active research program accompanied by demonstration projects in cooperative learning, but this remains at the fringes of the education system (Slavin et al., 1985). If the argument developed here is correct, then this area of research should be given more prominence.

One implication of the changing nature of work is that workers who have in the past been trained in vocational education programs increasingly need conceptual and problem-solving abilities traditionally expected of students in academic programs. Moreover, there is evidence that for some students it is easier to teach abstract concepts in applied courses such as those that are designed to prepare students for a particular job or occupation (Meyer, 1988). At the same time, cognitive psychologists have questioned the utility and wisdom of the deep distinctions between in-school and out-of-school mental activity

(Resnick, 1987b). These developments suggest the need to work toward integrating work-related and academic education. And this does not simply mean the elimination of vocational-type education, since traditional academic tracks could benefit from some of the concreteness, focus, and constituencies of the work-related programs.

Public policy to encourage firm-based training is controversial since it involves the possibility of public subsidies to private profit-making firms. Moreover, opponents of such subsidies argue that investments in human capital already receive more favorable tax treatment than investments in capital equipment—training costs can be written off immediately as a current expense while equipment must be depreciated over several years (Vaughan & Berryman, 1989). We could add that firms that pay for their workers to attend community colleges or who use customized programs at those institutions also already receive substantial subsidies since tuition at public community colleges usually covers less than one-half of the cost.

The public sector has a less controversial role in the two arenas associated with firm-based training. One of these involves support for workplace literacy programs where firms are doing what the public schools apparently failed to accomplish. Support for data collection, research, and information diffusion is a second, less controversial, area. As I have emphasized, available information on firm-based training is scarce and unreliable, and the public sector is in the best position to make progress in this area.

The public sector could also promote schemes to spread the cost of training among a large number of employers who require a particular set of skills. Employers complain that they lose their investment in training if the workers who receive the training leave; spreading the cost among many employers avoids this problem. This is the principle on which the construction apprentice system is based. The cost is spread among many employers and the workers end up with a recognized credential.

This principle also partly underlies a program used in some European countries. Employers are required to spend a given percentage of their wage bill on training. If they fail to spend enough, they must pay the deficit to the government. This is in effect a training tax, but it allows the firm to design and carry out the training. Assuming that the percentage is high enough and that firms do not simply exaggerate their training cost, this

system does promote training and education in a way that is completely integrated with the workplace.

Finally, as I have pointed out, the outside educational system already carries out about one-third of all formal employer-sponsored training. Also, many programs in post-secondary institutions, even if they are not formally linked to particular employers, in effect serve local industries either by training entry-level workers or by teaching skills needed for upgrading experienced workers. Improvements could be made in the coordination between these programs and the training needs of the local firms. But this must be done primarily through the knowledge and contacts of the staff at those educational institutions. This involves the use of advisory committees and programs to assure that local level staff are kept current with developments in the relevant industries.

The ongoing transformation of markets and technology in the economy is challenging the traditional distinctions between academic and vocational education and between work and education or learning. Employees at all levels of the firm will increasingly be engaged in a continuous process of learning. Schools too can benefit from a better understanding of the type of learning that goes on at the workplace. It is increasingly misleading to draw sharp distinctions between education in schools and colleges on the one hand and in the workplace on the other. Education is not shifting away from one and towards the other, but rather the two systems are becoming increasingly integrated. The policy challenge involves improving the coordination between the educational system and the workplace while maintaining and strengthening the distinct roles of the educational system in preparing the population for broad participation in society and in strengthening the economic opportunities of the less advantaged.

APPENDIX:
THE CHANGING OCCUPATIONAL STRUCTURE

In this report I have argued that developments in markets and changes in technology have changed the content of many jobs. In other words, the activities and responsibilities of textile machine technicians, bank clerks, junior accountants, or sewing machine operators are different now from what they were ten years ago. But changes in the skill level in the economy can come about as a result of shifts in the occupational structure. Even if the jobs of accountants and sewing machine operators did not change, the overall skill level (or required educational level) would rise if the number of accountants grew while the number of operators fell. This appendix examines trends in occupations in the United States over the last fifteen years and projected trends between 1988 and the year 2000 and argues that those occupations filled by workers with higher educational levels have grown and are projected to grow faster than occupations dominated by workers with lower educational attainment. The analyses are based on occupational projections by the Bureau of Labor Statistics (BLS) which were matched to educational data on the occupations from the Current Population Survey.

Table 1 presents data on the growth of broad occupational categories between 1976 and 1988. The first group of occupations in the table (executive, administrative, and managerial; professional specialty; technician and related support; and sales and marketing) all have educational levels, measured by the share of the workers in the occupation with at least some college, above the average for the economy as a whole. Since the mid-1970s, as a group, these higher level occupations have grown at almost three times the rate of the lower skilled jobs and although they still accounted for less than forty percent of employment in 1988, more than one-half of all of the net employment growth between 1976 and 1988 took place within the higher skilled occupations.

But what about trends between now and the year 2000? Proponents of the argument that skills will fall point to occupational forecasts that some occupations generally considered to require little skill will add large numbers of jobs to the economy over the next decade. Table 2 displays the ten occupations that are projected to add the most jobs to the economy by the year 2000. With the exception of registered nurses and general managers and secretaries, these jobs generally require low skills. These seven lower skilled

occupations are projected to account for about one-fifth of the total job growth between 1988 and 2000.

Although tales of the proliferation of fast-food workers and janitors have had a strong influence on public opinion, the absolute growth in particular occupations can be misleading. Large occupational categories with low rates of growth can still add many jobs. Indeed, since low-skilled jobs are less differentiated than higher skilled jobs, lower skilled jobs tend to be categorized in large groups.

The list of the fastest growing jobs is dominated by occupations characterized by middle level skills. Paralegals, medical assistants, radiologic technologists, and data processing equipment repairers are all among the top five. But this approach can also be criticized since fast-growing occupations can start from extremely low bases and therefore will contribute few actual jobs. The three fastest growing occupations listed above will account for only about one percent of the total net job growth by the turn of the century.

These problems can be avoided by looking at the occupational structure as a whole rather than focusing on selected jobs. Table 3 divides the occupational structure into the higher and lower level occupational categories that were used in Table 1. The trend toward higher skills that has characterized the last fifteen years will continue, although projections suggest that the trend may be somewhat weaker. In the past twelve years, the higher skilled occupations grew two and a half times as fast as the lower skilled occupations. Over the next twelve years, they are expected to grow just under twice as fast.

Table 4 extends this analysis by presenting data on the implications of these occupational projections for the distribution of education in the year 2000. The analysis is carried out as follows: First, the projected growth rates are used to calculate the total projected number of jobs in each occupational category. Then, the distribution of 1988 incumbents in each occupation among the four educational groups is applied to that total. For example, if forty-four percent of the managers in 1988 had a college degree, it is assumed that in 2000, forty-four percent will still have a college degree. This yields a year 2000 projection for the number of workers in each occupational category who are also in each educational group. Next, taking all of the occupations, the number in each educational category is summed, giving a projection for the total number of workers in each educational group. Thus, any change in the distribution of education results *only* from the differential

Table 1. Changes in the Occupational Structure, 1976-1988

Occupation**	Number Jobs 1988	Percent Distribution	Percent Growth 76-88	Percent of Total New Jobs 76-88	Educational Level*
Professional Specialty Occs.	14,628	12%	45%	17%	91%
Techn. and Rel. Support	3,867	3%	54%	5%	68%
Exec., Admin., & Manag.	12,104	10%	66%	18%	66%
Marketing & Sales	13,316	11%	46%	16%	47%
Subtotal	43,915	37%	51%	56%	69%
Administrative Support	21,066	18%	28%	17%	42%
Service Occupations	18,479	16%	28%	15%	24%
Prec. Prodctn., & Craft	14,159	12%	25%	11%	23%
Ag., For., & Fish.	3,503	3%	-8%	-1%	19%
Op., Fabr., & Laborers	16,983	14%	3%	2%	16%
Subtotal	74,190	63%	19%	44%	27%
TOTAL	118,105	100%	29%	100%	42%

* The percent of all individuals employed in this occupation who have completed at least one year of postsecondary education.

** Full Names of Occupations

Prof. Specialty Occs.	Professional Specialty Occupations
Tech. & Rel. Support	Technicians and Related Support Occupations
Exec., Admin., & Manag.	Executive, Administrative, and Managerial
Marketing & Sales	Marketing and Sales Occupations
Administrative Support	Administrative Support Occupations (Including Clerical)
Service Occupations	Service Occupations
Prec. Prdctn., & Craft	Precision Production, Craft, and Repair
Ag., For., & Fish.	Agriculture, Forestry, and Fishery and Related
Op., Fab., & Laborers	Operators, Fabricators, and Laborers

Source: Silvestri and Lukasiewicz 1989, Tables 1 and 8.

Note: Some columns may not add up due to rounding.

Table 2. The Ten Occupations with the Largest Absolute Growth

Occupation	1988 Employment	Absolute Job Growth (1988-2000)	Percent of Total Job Growth (1988-2000)
Salesperson, Retail	3,834	730	4.0 %
Registered Nurse	1,577	613	3.4 %
Janitors and Cleaners	2,895	556	3.1 %
Waiter, Waitress	1,786	551	3.0 %
General Managers	3,030	479	2.6 %
General Office Clerks	2,519	455	2.5 %
Secretaries	2,903	385	2.1 %
Nursing Aides and Orderlies	1,184	378	2.1 %
Truck Drivers	2,399	369	2.0 %
Receptionists and Clerks	833	331	1.8 %

Source: Silvestri and Lukasiewicz 1989: Table 6.

growth rates of the occupations. This is an assumption with a strong bias against change, since it assumes that no change takes place within each occupation.

Despite this conservative bias, the analysis suggests that the new jobs that are expected to be created over the next decade will have higher educational levels than current jobs. For example, seventeen percent of the current jobs are filled by workers who have not completed twelve years of school, while this share for new jobs created by 2000 will be only thirteen percent. The discrepancy between current jobs and new jobs for college graduates is even larger. According to this calculation, college graduates hold twenty-two percent of the current jobs while thirty percent of the new jobs will go to workers who have completed four years of college.

Can this change be attributed to "credentialing" or to "overeducation"? That is, does the increase of the educational level of workers come from more and rising education in the population that is not called for by the skill needs of employment? According to this view, if college graduates are available, employers will hire them rather than a high school graduate even if the high school graduate could do the job just as well. The credentialing argument suggests that it is misleading to judge educational needs (or the demand for education) by looking at changes in the average educational levels over time. It is possible that the supply of educated workers could rise simply because individuals want more education.

While this is possible, the rise in educational levels during the 1980s does not appear to reflect only an exogenous rise in the supply of education. If this were true, we should observe a decline in the wage differentials among the different educational classes, yet, as we have seen, these differentials are rising. Moreover, the particular analysis presented here cannot be influenced by any credentialing effect if it does exist. The analysis shows that jobs that are currently filled by workers with higher educational levels are expected to grow faster than those filled by individuals with lower levels of educational attainment. It assumes that over the next decade, employers will continue to fill each type of job with workers who have exactly the same educational level as the incumbents. Since the analysis only uses educational levels at one point (i.e., in 1988) it cannot be influenced by supply-induced changes in educational levels over time.

The analysis presented in Table 4 uses only nine occupational groups and it is possible that the results could change if a more detailed classification were used. The analysis using forty-six categories results in some tiny shifts (see Table 5).[4]

The accompanying figure ("Occupational Growth and Education") displays the relationship for the forty-six occupational groups between the share of the jobs in each group held by workers with at least some college and the projected growth rate. The trend line in the figure shows a strong positive relationship between the educational level of the occupation and the projected growth rate.[5]

In recent research, Levin and Rumberger (1987) have used an analysis of occupational projections similar to the one presented here to argue that the educational needs of the jobs that will open over the next decade may even be lower than the existing jobs. They used BLS occupational projections for the period 1982 to 1995 with 1980 Census data and concluded that "the educational requirements of new jobs over this period [1982-1995] will be almost identical to those of existing jobs in 1982." Moreover, they argue that analysts should also look at "replacement jobs—those arising from turnover" as well as new jobs since this will reflect the educational requirements of job openings. If replacement jobs are included, they contend, "then the educational requirements of job openings in the future will actually decline, simply because replacement opportunities are expected to be much higher among jobs with low educational requirements."

Why does their argument differ from the analysis presented here? First, more recent data gives a different picture. Second, the discussion of replacement needs is simplistic and misleading.

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[4]The educational data provided in the Silvestri and Lukasiewicz article was not sufficiently disaggregated to carry out the analysis using the forty-six categories. As a result, their data was supplemented by educational data from the 1988 public use sample of the Current Population Survey.

[5]Each of the points represents one of the forty-six occupations, but those occupations have varying numbers of workers. If these differences in size are not taken into account, then some distortion might occur. Therefore, the trend line displayed in the figure was computed after giving greater weight in the calculation to the larger occupations. The line was fit using the weighted least squares technique in which the number of workers in each occupation was used as the weight.

Table 3. Projected Changes in Occupational Structure, 1988-2000

Occupation[a]	Number of Jobs 1988	Percent Distribution 1988	Percent Growth 88-2000	Percent of Total New Jobs 88-2000	Educational Level[b] 1988
Professional Specialty	14,628	12%	24%	19%	91%
Technicians and Related Support	3,867	3%	32%	7%	68%
Executive, Admin., and Managerial	12,104	10%	22%	15%	66%
Marketing and Sales	13,316	11%	20%	14%	47%
Subtotal	43,915	37%	23%	55%	69%
Administrative Support	21,066	18%	12%	14%	42%
Service Occupations	18,479	16%	23%	23%	24%
Precision Production, Craft, and Repair	14,159	12%	10%	8%	23%
Agriculture, Forestry, and Fishery	3,503	3%	-5%	-1%	19%
Operators, Fabricators, and Repair	16,983	14%	1%	1%	16%
Subtotal	74,190	63%	10%	45%	27%
TOTAL	118,105	100%	19%	100%	42%

[b] The percent of all individuals employed in this occupation who have completed at least one year of postsecondary education.
[a] See Table 1 for the complete names of the occupations.

Source: Silvestri and Lukasiewicz 1989, Tables 1 and 8.
Note: Some columns may not add up due to rounding.

Table 4. Projected Occupational Growth and Education

Occupations	Jobs 1988	Projected % Growth 1988-2000	Percent of Total Employment in 1988 in Each Occupation with: Less Than HS	HS Only	1-3 Yrs. Col.	4 or More Yrs. Col.
Exec., Admin. & Manag.	12,104	22.0%	5%	27%	24%	44%
Prof. Specialty Occs.	14,628	24.0%	2%	9%	15%	74%
Tech. & Rel. Support	3,867	31.8%	3%	29%	36%	32%
Marketing & Sales	13,316	19.6%	13%	39%	24%	23%
Administrative Support	21,066	11.8%	7%	51%	30%	12%
Service Occupations	18,479	22.8%	31%	45%	18%	6%
Ag., For., & Fish.	3,503	-4.8%	36%	44%	12%	7%
Prec. Prodctn. and Craft	14,159	9.9%	23%	53%	18%	5%
Ops., Fab. & Laborers	16,983	1.3%	33%	51%	12%	4%
Total (Percentages)	118,105	15.3%	17.0%	40.5%	20.7%	21.8%
Net New Jobs (1988-2000)	18,068		13.2%	35.0%	22.1%	29.7%

See Table 1 for the full name of the occupations

Source: Silvestri and Lukasiewz 1989, Tables 1 and 8.

Table 6 displays the educational distribution for 1982 and for the new jobs projected for the following thirteen years (Levin & Rumberger, 1987) and compares them to the educational distributions for 1988 and for the new jobs projected for the following twelve years (taken from Table 4). This data shows that seventeen percent of the employed workers in 1982 had four or more years of college while the Levin and Rumberger projections suggested that only eighteen percent of the new jobs created between 1982 and 1995 would be filled by college graduates. Workers with no more than twelve years of schooling accounted for sixty-four percent of all workers in 1982, but, according to Levin and Rumberger, would fill sixty percent of the new jobs. Thus, the 1982 data shows a higher share of the lower level jobs than the 1988 data, and the projections made using 1982 data shows a much slower growth of higher level jobs than the later projections.

First, it is possible to check the accuracy of the 1982 projections using current data. In the six years following 1982, the share of the employed population with no more than a high school degree fell from sixty-four to fifty-seven percent. In 1988, the *total* employed population had a higher educational level than the people in the *new* jobs that were projected to be created by 1995; thus, the earlier projections underestimated the shrinkage of low level jobs. Given the rising wage differential between college and high school, earlier projections underestimated the shrinkage of low level jobs. And given the rising wage differential between college and high school graduates, this growth cannot be attributed merely to credentialism.

Furthermore, the educational distribution of net new jobs projected in 1982 and those projected in 1988 contrast sharply. The earlier projections foresaw virtually no growth in the share of college graduates, while the latest numbers indicate strong relative growth for this group.

The use of the replacement data gives the impression that the emerging job "opportunities" actually require less education than the current jobs. The replacement data that these authors use is based on an analysis by the BLS that matches data from two successive years of the Current Population Survey (Eck, 1984). Many individuals are in the sample for two years and it is therefore possible to compare their activity during those years. "Separations" occur if individuals who are in one occupation during one year are no longer in that occupation the following year, either because they have transferred to another occupation or because they are not working. In the case of occupations with growing

employment, replacement needs are equal to separations (total job openings are equal to replacement needs plus growth). In shrinking occupations, replacement needs are equal to separations minus net job decline. Primarily because workers in low-skilled jobs turn over rapidly, separations are much higher for lower skilled jobs with less-educated incumbents, than for occupations dominated by college graduates. (Fifty percent of all dishwashers but only 1.4% of all physicians "separate" each year.)

Whether or not replacements should be included in an analysis of the characteristics of emerging jobs depends on the question being asked. Replacement data gives a sense of the nature of job openings. This is of course important for an individual looking for a job. Even in shrinking occupations, jobs open up because of replacement needs. Replacement data might also have educational implications. For example, many more nurses would need to be trained if nursing careers lasted only five years instead of thirty-five.

But if we are interested in gauging the general trajectory of the economy and the needed skills, then the replacement data is misleading. An example can make this clear: There are three occupations, each with one hundred incumbents at the beginning of a period—two require no education and the third requires many years of education. At the end of the period, the high-skilled job has grown by ten percent and the low-skilled jobs have each shrunk by ten percent. Therefore, there are now one hundred and ten high-skilled and only one hundred and eighty low-skilled positions. This would seem to be a clear movement toward a higher skilled economy.

But replacement data might suggest the opposite conclusion. If all one hundred high-skilled workers stayed on the job, but if by the end of the period ten percent of the workers in each of the two low-skilled jobs were not working and if another twenty percent of each occupation simply switched to the other low-skilled occupation (e.g., the dish-washers got jobs as janitors), then, according to the data that Levin and Rumberger use, there would be forty "replacement opportunities" in the low-skilled occupations, but only ten new job opportunities in the high-skilled occupation. Thus, it would appear that the new opportunities had lower educational requirements than the jobs that existed at the beginning of the period. However, these openings in the low-skilled positions recorded by replacement data all resulted from a churning among the lower level jobs, and not a single

Table 5. The Distribution of Net New Jobs
The Effects of Different Occupational Disaggregations

Level of Disaggregation	Less than HS	HS	Some College	Four or More Years of College
9 Categories	13.2%	35.0%	22.1%	29.7%
46 Categories	12.6%	35.0%	23.3%	29.1%

Source: Silvestri and Lukasiewicz 1989 and the 1988 Current Population Survey Public Use Sample

Table 6. 1982 and 1988 Occupational Projections

	HS or Less	Some College	Four or More Years of College
Total Distribution			
1982 (Levin and Rumberger)	64.0%	19.0%	17.0%
1988	57.6%	20.6%	21.8%
Distribution of New Jobs			
(1982-1995) (Levin and Rumberger)	60.0%	22.0%	18.0%
(1988-2000)	48.2%	22.0%	29.8%

Source: Silvestri and Lukasiewicz 1989; Levin and Rumberger 1987.

new worker was needed for the low-skilled occupations taken as a whole, while ten new workers were recruited for the high-skilled occupations.

This is not to say that it is not important to consider the implications of the need to replace workers who leave the labor force, but the available replacement data combines so many phenomena that they can give a false impression of the underlying changes in the job structure. Given the much greater frictional changes in the lower level jobs, replacement data will tend to exaggerate the importance of those low level positions. It would be important to consider changes in turnover rates and career trajectories over time (e.g., if the average length of nursing careers changes significantly), but the replacement data used by Levin and Rumberger gives no indication of this. Thus, if we are trying to understand changes in the underlying occupational structure, given current data, it makes more sense to examine changes in the distribution of occupations entering the economy than to focus on job openings generated by replacement needs.

In sum, the occupational data does not reveal an increase in low level jobs. Nor are the educational levels of new jobs more or less the same as those for current jobs as Levin and Rumberger argue. At the very least, this data shows a steady increase in those occupations that tend to employ more highly educated workers. Moreover, the techniques used here to evaluate the trends in educational levels have a strong bias against change. In effect they are based on the assumption that change can only take place among the new jobs. If this assumption were valid, then, since the Bureau of Labor Statistics expects employment to grow by only twenty percent over the next twelve years, in the year 2000 about eighty percent of the jobs would have exactly the same skill requirements as they do now. The case studies suggest that there are important changes taking place within that eighty percent.

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